STATUS OF MINERAL RESOURCE INFORMATION FOR THE BIG CYPRESS, BRIGHTON, AND MICCOSUKEE INDIAN RESERVATIONS, FLORIDA

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Administrative Report BIA-35
1977

CONTENTS

SUMMARY AND CONCLUSIONS

Much of the mineral potential of the Florida reservations is being developed. Continued sand production and drilling for oil and gas offer the best prospects for the future.

Big Cypress Reservation has an operating silica sand pit. One producing oil well of the Seminole Field is on the reservation and additional drilling is planned. If a proposed well for eastern Big Cypress Reservation has encouraging results, interest in oil exploration on Miccosukee Reservation may develop. No other mineral development is possible for the Miccosukee Reservation at this time because it is part of a water conservation area in which mining is prohibited. Brighton Reservation has a small marl pit that provides material for local road construction. Marl is abundant in southern Florida and probably no expansion of this type of mining is possible. There is potential for a silica sand deposit and less potential for a heavy minerals concentration. Thin peat deposits and low grade phosphate are found in several places on the reservation.

A drilling program is recommended for both Big Cypress and Brighton Reservations to delineate the boundaries of the known silica sand deposit and to prospect for additional deposits. On Brighton Reservation, this drilling should be expanded to include testing for heavy minerals concentrations.

INTRODUCTION

This report was prepared for the U.S. Bureau of Indian Affairs by the U.S. Geological Survey and the U.S. Bureau of Mines under an agreement to compile and summarize available information on the geology, mineral and energy resources, and potential for economic development of these resources on certain Indian lands. Big Cypress and Brighton Reservations, both under Bureau of Indian Affairs jurisdiction, and Miccosukee Reservation, under the jurisdiction of the State of Florida, are discussed in this report (Figure 1). The 430-acre Hollywood Reservation is not included because of its location in urban Hollywood, Florida, where this land is of great value to the tribe for commercial and tourist trade development. Also not included is the 333.3 acres along the Tamiami Trail that the Miccosukee tribe holds under 50-year lease from the National Park Service. Since no commercial or industrial development is permitted on this land, it did not seem feasible to include it in this survey.

Sources of information were publications and communications with people familiar with mineral resources of the area. Staff members of the Florida Bureau of Geology, U.S. Bureau of Indian Affairs, U.S. Corps of Engineers, and members of the Seminole Tribe provided unpublished information that contributed to this report. No field work was conducted.

PAST INVESTIGATIONS

The geology and ground water resources of the area that includes the reservations have been the subjects of reports by the U.S. Geological Survey in cooperation with the Florida Geological Survey (Parker and Cooke, 1944; Parker and others, 1955; Klein and others, 1964; McCoy, 1962). Reports on

various mineral commodities for the whole state include reports on peat (Davis, 1946), phosphate (Mansfield, 1942), and petroleum (Rainwater, 1971; Winston, 1971a and 1971b; Fietz, 1976; Tyler and Erwin, 1976).

PHYSIOGRAPHY

Most of southern Florida is part of the coastal lowlands which have been divided into fairly distinct physiographic regions by Davis (1943, p. 41). Three of these, the Everglades-Lake Okeechobee Basin, the sandy flatlands, and the Big Cypress Swamp, cover the parts of Broward, Glades, and Hendry Counties that include reservation lands (Figure 2).

Everglades-Lake Okeechobee Basin

Lake Okeechobee is the head of a nearly flat shallow basin, called the Everglades, that extends for 100 miles to the southern coastal marshes and mangrove swamps. The average width is about 40 miles; elevations on the ground surface range from 16-17 feet above sea level near the north central part to 5-8 feet near the Tamiami Trail, and near sea level at the southwestern end of the basin near the coast. The average slope is about one foot for every six miles. The Everglades is an area of organic soils, muck or peat, lying directly on limestone or marl which form most of the basin floor (Davis, 1943, p. 43). The organic material is thickest (7-9 feet) near Lake Okeechobee and thins to the south. The Miccosukee Reservation is mostly within the Everglades but includes a small part of the Big Cypress Swamp along the southwestern edge.

Big Cypress Swamp

The Big Cypress Swamp is bounded on the east and south by the Everglades and on the north by the sandy flatlands (Figure 2). Altitudes range from 20 feet or more in the northern part to 5 feet or less in the southern part and are generally less than 15 feet (Davis, 1943, p. 48). The soil in the swamp in Hendry County is chiefly sand or loam (Klein and others, 1964, p. 9), but large areas throughout the swamp have rock near the surface or have only a thin marly soil. This is in contrast to the Everglades where there are no rock outcrops and soils are mucky (Parker and Cooke, 1944, p. 44). The surface of Big Cypress is generally flat but marked by small higher hammock areas which support grass, palmettos, and pines in contrast to the low cypress, sedges, and marsh plants of the swamp region. The Big Cypress reservation is partly within the Big Cypress Swamp (Figure 2).

Sandy Flatlands

The sandy flatlands, the largest physiographic unit in Glades and Hendry Counties (Klein and others, 1964, p. 7) cover the whole of the Brighton Reservation. A minor subdivision, the Istokpoga Indian Prairie basin covers the northeast half of the reservation (Figure 2). Surface altitudes range from 10 feet to more than 70 feet above sea level. Most of the area in Hendry and Glades Counties is less than 30 feet above sea level and is covered by sand deposited as marine terraces during the Pleistocene

time (Alt and Brooks, 1965, p. 409-410). The latest Pleistocene shore line is 25 to 30 feet above sea level and lies along the northwest edge of the Brighton Reservation.

GEOLOGY

Stratigraphy

Peninsular Florida has been formed by sediments accumulating on a backbone of ancient crystalline rock (Parker and Cooke, 1944, p. 18). Distribution of Pre-Mesozoic rocks are shown on Figure 3. Sedimentary rocks of the Coastal Plain, ranging in age from Late Jurassic(?) or earliest Cretaceous(?) to Recent, cover the older rocks in the core of the Florida peninsula, but in the southern part of the state formations older than Late Miocene are known only from subsurface information. Wells drilled to test for oil show that the basement rocks are at least 12,618 feet below the surface in Highlands County about 20 miles west of the Brighton Reservation and are more than 12,800 feet below the surface in the northeastern corner of the Big Cypress Reservation, Palm Beach County (Figure 3), where a well bottomed in rocks of Lower Cretaceous age. The well in Highlands County penetrated old volcanic rocks and is the southernmost well in the state to reach the basement (Applin and Applin, 1965, p. 11). Table 1 lists the generalized stratigraphic sequence in the area that includes the 3 reservations discussed in this report. Figure 4 and Figure 5 depict the general structural features, and stratigraphic succession in a north-south section. Figure 6 is a map of the surface geology in the area that includes the three reservations.

Structure

The South Florida basin is bounded on the western flank by the Early Cretaceous reef trend located along the Florida escarpment (Antoine and others, 1967; Bryant and others, 1969), on the northeast by the Peninsula Arch, on the northwest by the Middle Grounds Arch, and on the southern flank by the Pine Key Arch (Winston, 1971a) (Figure 7). The eastern portion of the basin, where the rocks are characterized by shelf-type facies, has been designated as the South Florida Shelf (Applin and Applin, 1965). The subsurface rocks of the Indian reservations are located near or on this shelf. West-southwest of the shelf is the synclinal axis of the South Florida embayment (Pressler, 1947), a region which is nearly synonymous with the South Florida basin. The axis of the embayment appears to coincide with the central and deepest part of the South Florida basin.

On the shelf proper, at the Sunniland level, regional dip of the sedimentary strata is to the southwest at the rate of about 20 feet per mile (Fietz, 1976; Tyler and Erwin, 1976). Dips from 60 to as much as 155 feet per mile, however, are found in specific areas where low relief structures and patch reefs are present (Fietz, 1976; Tyler and Erwin, 1976). It is these isolated patch reefs and bioclastic banks, mounds, or pods, with only very subtle relief, that constitute the present oil reservoirs in the Sunniland trend.

MINERAL RESOURCES (REGIONAL)

General

Mineral resources that might be expected in the region are limited to construction materials, such as limestone, sand, and clay; fertilizer materials, such as phosphate, limestone, marl, and peat; and organic fuels, mainly oil but also peat. Metallic deposits, either as heavy mineral concentrations or as sedimentary accumulations of oxides or sulfides, are not as likely to be found in economic concentrations. Broward County produces stone, sand, and gravel from deposits that are mainly near the coast. Glades County produced sand and gravel in 1974, and Hendry County produces oil, gas, sand, and gravel.

Energy Resources

General

Known energy resources of the region that includes the reservations are limited to petroleum and peat. It is possible that very low concentrations of uranium occur in the phosphate but in the reservation areas, such concentrations remain to be proven. Peat deposits are described under nonmetallic mineral resources.

Petroleum

General.--To date, the Sunniland Limestone of Lower Cretaceous (Trinity) age is the only oil-producing formation in the South Florida Basin. Present production is from the Sunniland trend that extends northwest from the abandoned Forty Mile Bend field in Dade County to the LeHigh Park field in Lee County (Figure 8). The Big Cypress and Miccosukee Reservations appear to be within the edge of the producing trend.

The major petroleum target in the South Florida basin is the Sunniland Limestone of Lower Cretaceous age that yields oil from a depth of about 11,500 feet. The formation (Table 1) averages about 280 feet thick.

The Sunniland can be divided into a lower zone about 100 feet thick and an upper zone about 200 feet thick. The lower part of the lower zone is characterized by dense, dark brown to gray, highly fractured, calcilutitic limestone. Because it is fractured, cores are usually recovered as broken and shattered pieces of rock resembling a pile of rubble and giving rise to the common name of "Rubble Zone." The "Rubble Zone" also yields oil but so far only from the one-well Lake Trafford field in Collier County.

Above the "Rubble Zone" is a series of dark gray shaly limestones or highly calcareous shales that many oil geologists believe are the oil source rocks for the upper Sunniland reservoirs. These rocks, however, are not known to contain commercial oil. The upper Sunniland zone is composed of tan to light grey foraminiferal, fine grained, chalky and argillaceous limestones and porous and permeable bioclastic carbonates. It is these bioclastic carbonates that build up into patch reefs or mounds that are the principal reservoirs in the Sunniland trend. At least three porous, permeable units in the upper Sunniland zone produce oil in the various fields. For accurate evaluation, coring of at least

the upper Sunniland zone and testing of any oil shows is highly recommended.

The next most important objective in the South Florida basin is the series of rocks of Fredericksburg age which occur at a depth of 9,300 feet or approximately 2,000-2,200 feet above the Sunniland. Although no commercial accumulations of oil have been found to date, the Fredericksburg nevertheless has attracted the attention of the oil industry because of numerous reported oil shows and abundant potential source rocks. According to Winston (1971b) who has published the most extensive study of the Fredericksburg, the greatest potential for oil production lies in the Dollar Bay Formation (particularly unit C), which makes up the upper part of the Fredericksburg. At least twenty-six oil shows have been reported in units of the Dollar Bay Formation including one that consisted of 15 feet of oil recovered from a 20-hour drill stem test. The Dollar Bay Formation consists of light to dark gray, dense, argillaceous, stylolitic limestones, many of which are of good source-rock quality, and as much as 120 feet of porous and permeable carbonate reservoir beds (Winston, 1971b). Thus, second only to the Sunniland, the Dollar Bay Formation should require careful scrutiny in those areas where the reservoir development is possible.

Another stratigraphic unit that holds some promise for producing oil is the "Brown Dolomite" zone of Lower Trinity age found some 1,000 feet below the Sunniland Limestone. No commercial oil as yet has been recovered from this zone but it is characterized by excellent porosity and permeability and is reported to contain oil shows. Because of its greater depth, relatively few wells have penetrated this zone and hence there are insufficient data to properly assess its source-rock and oil-producing potential.

The prospect for finding commercial oil accumulations in some of the remaining stratigraphic units cannot be discounted but a diligent search would be required to locate such deposits. In addition to detailed stratigraphic analysis and sophisticated geophysical measurements, greater effort should be given to organic geochemical studies for source rock potential and eventual oil-source rock correlations. The availability of more core samples especially from the more promising but as yet unproductive horizons would be invaluable not only from the standpoint of more accurate organic geochemical analyses, but also for more detailed and meaningful lithologic descriptions and better determinations of porosity and permeability.

The stratigraphic units that exhibit some degree of oil potential are as follows. Several units, chiefly dolomites, within a sequence of rocks that extend from the lower part of the Paleocene Cedar Keys Formation to the upper part of the Upper Cretaceous (Gulfian), at depths between about 4,500-5,500 feet, have some reported oil shows. These rocks are buried only to shallow depths and hence are probably thermally immature (i.e., rocks not subjected to high enough temperatures over an adequate period of time to have generated substantial amounts of crude oil). Nevertheless the presence of oil shows certainly warrants careful attention to these zones.

The lower 350 feet of Gulfian rocks at a depth of about 8,000 feet have some surprisingly organic-rich beds that seemingly are potential oil source rocks (Palacas, 1977). The organic carbon

content (a measure of the total organic matter, the raw material necessary for hydrocarbon generation) for these carbonate beds averages 0.54 percent, and is as much as 3.19 percent. Under the proper geologic conditions, i.e., when in juxtaposition to porous and permeable beds, having the necessary stratigraphic or structural trap features, and in areas of higher geothermal gradients, these organic-rich beds should act as effective source rocks.

In the sequence of rocks of Upper Trinity age or Lower Fredericksburg age (depending upon the stratigraphic classification that is followed), at an average depth of 9,950 feet (in the Big Cypress reservation area, about 9,850 feet) there are at least several beds, with a combined thickness of 20 feet that are classed as good potential source rocks (Palacas, 1977). The average organic carbon content of these beds is 1.2 percent. In addition, oil shows have been reported within and adjacent to these beds. Consequently porous, permeable rocks contiguous to these source rocks should be looked for and examined carefully as potential oil reservoirs.

Finally, in the sequence of rocks of Lower Trinity age, some 700-800 feet below the Sunniland Limestone, there are several beds that are considered as good potential source rocks. The organic carbon ranges 0.51-1.77 percent and averages 1.0 percent.

History and Production.--The history of oil and gas exploration in South Florida can be divided into three major periods (Fietz, 1976). The first period, 1920-1942, was marked by the drilling of relatively few unsuccessful wildcat wells. Most of these wells were shallow, and prior to 1939 were drilled to less than 4,000 feet. The first "deep" test, Peninsula #1 Cory, in sec. 6, T. 55 S., R. 34 E., Monroe County, was drilled in 1939 to a depth of 10,006 feet. It penetrated only the top of Trinity age rocks and did not reach the important Sunniland zone.

The discovery of the Sunniland field in Collier County in 1943 ushered in the second period of petroleum exploration, 1943-1963, and sparked considerable geophysical activity, leasing, and drilling. The Humble Oil and Refining Company (now Exxon Company) #l Gulf Coast Realties Corporation discovery well penetrated the Sunniland formation and on initial test pumped 110 barrels of 20º API gravity oil and 475 barrels of salt water per day from a bioclastic limestone interval at 11,613-11,626 feet.

During the second exploration period, 55 Sunniland wildcat wells were drilled for an average of about 2.6 wells per year. The results were disappointing with only one non-commercial oil field being discovered. The only glimmer of hope was the discovery in 1954 of the Forty Mile Bend field in Dade County by the Gulf Refining company et al.'s #l Wisehart-State of Florida well which produced from the Sunniland Limestone at 11,322-11,339 feet. This field, however, was short-lived and was abandoned in 1956 after producing only 32,888 barrels of oil (Rainwater, 1971).

Although exploration activity had dwindled, it increased again in 1964 when the Sunoco Oil Company #2 Red Cattle Company was completed as the discovery well of the Sunoco-Felda field, located in Hendry County. The well pumped 427 barrels of oil per day from the Sunniland Limestone in the interval 11,472-11,485 feet (Babcock,

1966). The Sunoco-Felda field has produced 8,122,000 barrels of oil up to May 1976 and the estimated in-place oil reserves are 44 million barrels of oil. Exploration activity in the South Florida basin has continued at an increasing rate up to the present and from 1964-1975, 99 Sunniland wildcats were drilled giving rise to a rate of 8.25 wildcat wells per year in contrast to 2.6 wildcats per year in the previous period. During this period six new fields were discovered, namely, West Felda, Lake Trafford, LeHigh Acres, Bear Island, Seminole and LeHigh Park. Production data for each of the fields are shown in Table 2.

TABLE 2
Production Data of South Florida Oil Fields (after Fietz, 1976)

Field name	Year discovered	Productive acres	Daily oil prod. barrels May 1976	Cumulative oil prod. 1000 barrels May 1976
Sunniland	1943	2,400	1,332	16,577
Forty Mile Bend	1954	320	abnd. 1956	32
Sunco-Felda	1964	4,500	1,588	8,122
West Felda	1966	6,400	8,527	19,516
Lake Trafford	1969	160	S.I.	134
LeHigh Acres	1970	COMBINED WITH WEST FELDA FIELD		
Bear Island	1972	1,280	967	736
Seminole	1973	320	62	42
LeHigh Park	1974	320	536	118
TOTALS			13,013	44,145

Nonmetallic Mineral Resources

General

Non-metallic mineral resources of the region include construction and fertilizer materials. Examples of nonmetallic resources are high-silica sand, limestone, phosphate rock, marl and peat.

Construction Materials

Limestone.--Limestone is an important mineral resource of the region. Some limestone is mined in eastern Broward County and in Dade County to the south. The rock is present in the subsurface in all three reservation areas and is found in most of the Mesozoic and younger formations (Table 1). The quality and thickness of limestone varies widely from formation to formation; drilling would be necessary to determine tonnage and value of limestone in any specific area. Much of the limestone in all the reservation areas probably lies below sea level; mining operations would probably affect the ground water systems and would have to be carefully planned to avoid environmental hazards.

In addition to limestone, coquina has been produced for use on reservation roads.

Sand.--Sand deposits in the region are related to Pleistocene marine terraces. Sand is in short supply in Florida, particularly in Ft. Lauderdale, the nearest large city. Sand pits adjacent to Fort Lauderdale are limited in development by urban expansion from the east and restrictions on mineral development in the water conservation areas to the west. Florida highway specifications require 100 percent silica sand for grade A highway construction (David Jones, written commun., 1969).

Fertilizer Materials

Phosphate.--Phosphate resources in Florida are large (Mansfield, 1942; Cathcart and Gulbrandsen, 1973) and phosphate mining is active in Polk and Hamilton Counties. Deposits in Polk County are in the Bone Valley Formation of Pliocene age and the underlying Hawthorn Formation and are a part of the land-pebble phosphate district of Polk, Hillsborough, Manatee, Hardee, and De Soto Counties (Altschuler and others, 1956, p. 497) about 40 miles northwest of the Brighton Reservation.

In Glades and Hendry Counties phosphate nodules and phosphatized fossil fragments are disseminated in the Caloosahatchee Marl. In some areas concentrations of 100 tons of phosphate per acre foot may be present locally and hypothetical-phosphate resources of Glades County may be as much as 50 million tons (Cathcart, oral commun., 1971). For comparison, the oregrade material in the land-pebble district is generally considered to be at least 300 tons of phosphate per acre foot.

Phosphate is also present in the Hawthorn Formation in the three-county area including the reservations as disseminated nodules that range from fine sand to cobbles. Much of the Hawthorn is probably too deep to be considered as an important source of phosphate in Glades, Hendry or Broward Counties at this time.

Peat.--The peat resources of Florida were studied by Davis (1946) who gave a detailed description of properties, uses, and reserves. Peat is classified today into three general types: moss peat, reed-sedge peat, and peat humus. According to the American Society for Testing and Materials Committee D-29, Subcommittee I (Am. Soc. Testing and Materials, 1969) which has set up a standard classification (ASTM Designation D2607-69): "the term peat refers only to organic matter of geologic origin, excluding coal, formed from dead plant remains in water and in the absence of air. It occurs in a bog, swampland, or marsh, and has an ash content not exceeding 25 percent by dry weight." The classification lists five major plant types according to genesis and fiber content. Percentages of fiber are based on oven-dried weight at 105ºC, not on volume. The five types are 1) Sphagnum moss peat, 2) Hypnum moss peat, 3) reed-sedge peat, 4) peat humus, and 5) other peat (Cameron, 1973, p. 506). Peat is used today in the United States principally as a soil conditioner but energy uses may become important again. Florida is a major peat-producing state; all the producing areas, however, are in the central or northern parts of the state. The principal resources of peat in the state are in the Everglades. The Miccosukee Reservation in western Broward

County has the only extensive peat resources of the three reservation areas. The Istokpogo marsh northwest of the Brighton Reservation is another large resource area.

According to Davis (1946, p. 122) the peat in western Broward County ranges in thickness from 0 to 5 feet. It is mostly Loxahatchee peat that is formed in open-water or aquatic marshes. Loxahatchee peat is more acid than other peats and is generally considered non-agricultural soil because of its low ash content, labile organic material, and high degree of subsidence when drained (Gleason and others, 1974, p. 294).

Davis (1946, p. 115) estimates 128 million tons of Loxahatchee peat in 255,000 acres of Broward County. The peat averages 125 tons per acre foot, air dried. Probably at least two-thirds of the 76,000 acres of the Miccosukee Reservation have a thin, 1-5 foot cover of Loxahatchee peat, and, assuming an average of three feet of peat, the hypothetical peat resources are about 20 million tons, air dried. Calculated in a similar manner, the peat resources of the 28,000 acres of the Brighton Reservation in Broward County probably are about 8 million tons. How much of this peat could be mined without damage to the water resources of the area is not known. More detailed studies both of quantity and quality of the peat and of the environmental hazards related to mining are needed.

Heavy Minerals

Heavy-mineral mining has been a small but important Florida industry over the past sixty years (Garnar, 1972, p. 17) with some deposits yielding ilmenite, zircon, rutile, monazite and staurolite. Operating mines are on deposits along Trail Ridge in the northern part of the state. The deposits were formed by reworking of sand from the Lake Wales Ridge which is part of the central highlands that extends from the northern part of the state to southern Highlands County just west of the Brighton Reservation. The only known data on heavy mineral content of the southern part of the highlands are from a series of holes drilled by the U.S. Bureau of Mines near Lake Childs, Highlands County (Thoenen and Warne, 1949, figs. 13 and 20). A few small concentrations of heavy minerals were found.

BIG CYPRESS RESERVATION

Introduction

Big Cypress Reservation (Figure 9) consists of 70,700 acres in parts of Hendry, Broward, and Palm Beach Counties. That portion of the reservation in Hendry County contains 42,700 acres and is under Federal administration. The remaining 28,000 acres in Broward and Palm Beach Counties are under State supervision.

There are no private land holdings in the reservation; all surface and mineral rights are owned by the Seminole Tribe. On the Miccosukee-controlled part of the reservation, from the canal eastward (Figure 9), there are restrictions on land use. An easement of Water Conservation Area 3 prohibits activities other than boating, hunting, and fishing.

The only convenient access to the reservation is a Government-built road that crosses approxi-

mately 6 miles of the Miccosukee State reservation to connect with Everglades Parkway, State route 84. This is a toll road linking major markets in Fort Lauderdale on the Atlantic coast and Naples on the Gulf Coast. Tolls on the Everglades Parkway must be considered as a factor in any evaluation of mineral resource development.

Reservation lands lie in the area where Big Cypress Swamp and the Everglades imperceptibly merge. Big Cypress Swamp is distinguished from the Everglades by hammocks, islands of drier land that support pine and cypress trees. Before construction of drainage canals, most of the land was poorly drained and covered by low vegetation. Although the topography has little relief, there are many minor depressions and elevated areas (Davis, 1943, p. 123) that may be the result of solution in limestone bedrock. These small depressions frequently have no surface drainage and rainfall is commonly dissipated by underground seepage or transpiration. Where there is surface run-off, it is through sloughs that may be drained by sheet flow rather than by creeks.

Geology

Part of Big Cypress Reservation has thin soil cover and bedrock is visible in many drainage ditches. Tamiami Formation of Miocene age is the oldest formation and is present in the southern part of the reservation in Hendry County. Pleistocene and Pliocene formations form bedrock over the remainder of the reservation--the Caloosahatchee to the north and Fort Thompson to the east (Figure 6). Unconsolidated sands of the Pamlico terrace (Pleistocene) cover part of the reservation.

Although no faulting or folding is recognized in surface formations, there is a flexure which can be detected at depths greater than 5,000 feet (Maher and Applin, 1971, p. 57).

Mineral Resources

General

Sand and petroleum are currently being extracted from the reservation. Limestone and marl are available for local road construction. Thin peat accumulations and phosphatic material have been reported in drainage canal borings.

Nonmetallic Mineral Resources

Sand.--A Pamlico terrace deposit of high-quality silica sand with low tannic acid content is mined on the reservation. Although the material is high silica, it is used for concrete aggregate in highway construction. The deposit ranges from 20 to 35 feet thick with no overburden. Discovery was made by Meekins, Inc., after an extensive drilling program. A 640-acre tract (Figure 9) that is expected to yield 30,000,000 tons of sand (Jones, 1969) was leased from the tribe.

Drill holes outside the leased acreage indicate additional tonnage is present to the southeast and southwest. However, 3 miles to the east, Corps of Engineers' borings show the sand to be thin or absent.

A shortage of silica sand in Fort Lauderdale permits competitive pricing despite distance (50 miles) from the reservation.

Peat.--The reservation lies on the edge of the major Everglade peat deposits. An isopach map in Davis' "Peat deposits of Florida" (1946) indicates 7 feet of peat might be found in the northeastern part of the reservation. Corps of Engineers' borings (Figure 9) on Big Cypress Reservation (Schroeder and Klein, 1954, p. 13-14), show the following:

Boring number	Peat thickness (feet)	Description
23	3.0	dark brown, 1 foot; sandy peat and muck, 2 feet
24	4.3	mucky, dark brown
25	3.4	muck and peat, dark brown
26	5.4	brown

Borings on the Miccosukee Reservation immediately south show a rapid decrease in peat thickness; 2½ feet or less is present. North of the reservation, borings show almost no peat.

Based on limited information provided by the borings, thicker peat on Indian lands appears to be restricted to T. 48 S., Rs. 35 and 36 E.

Phosphate.-- The nearest active phosphate mining is more than 100 miles northwest of the reservation. No phosphate has been mined in or near the reservation. It is reported in literature that the "Buckingham" Marl is phosphatic, and Cooke (1945, p. 212) stated that it "may have potential as a source of phosphate." The Buckingham Marl is now included in the Tamiami Formation, bedrock in the southern part of the reservation.

Phosphate is reported in Corps of Engineers' borings in Hendry and Broward Counties (Table 2) and the most frequent occurrence is in the borings form the reservation. The phosphatic material is not restricted to the Tamiami Formation but occurs in the Caloosahatchee Marl and Fort Thompson Formation. The amount of phosphate in these formations is probably low. Depth of overburden and thin phosphate-bearing beds limit their value as a resource.

Energy Resources

Oil.--The Seminole Field in Hendry County is partly on the Big Cypress Reservation (Figure 8). Initial production from the discovery well was 26 barrels of oil per day (Cate, 1974).

Statistics reported to the Florida Bureau of Geology during the period May to October, 1976, show:

Seminole Tribe Well #18-3 (on pump)

	Oil (barrels)	Water (barrels)	Days operating	Gravity (°API)
May	367	4,936	23	24
June	143	1,923	8	24
July	238	3,201	19	24
August	304	4,089	25	24
September	277	3,726	25	24
October	106	1,426	6	24

Two new drilling permits have been issued for T. 48 S., R. 32 E., but as of January 1977, drilling had not commenced (Matlock and Starling, 1977). Five wells have been drilled on the Reservation but only one is a producer (Figure 10). The Humble #1 State Lease 1004 (sec. 2, T. 48 S., R. 35 E., Palm Beach County), the Mobil #l Seminole Tribe (sec. 8, T. 48 S., R. 33 E.), and the Phillips #1 Seminole Tribe C (sec. 28, T. 48 S., R. 33 E.), drilled in 1957, 1970, and 1972, respectively, had reported good to excellent oil shows in the Sunniland Limestone and Fredericksburg rocks but apparently neither adequate reservoir rock nor the necessary structural or stratigraphic entrapment conditions were developed, and hence, all were abandoned.

About 0.1-0.2 miles west of the reservation, the Weiner #l Oleum, sec. 12, T. 48 S., R. 32 E., was drilled in 1973 as the discovery well for the Seminole field. On initial test it produced 26 barrels of oil per day (BOPD) from the Sunniland at a depth of 11,460 feet. As of May 1977 it was producing about 60 BOPD.

The second well to join the Seminole field was drilled in 1975 as the Kanaba #18-3 Seminole Tribe, sec. 18, T. 48 S., R. 33 E., in the Big Cypress Reservation. As of May 1977, the estimated production was about 15 BOPD.

A third well was added to the field, but outside the Reservation, when the Diamond Shamrock #13-3 Oleum in sec. 13, T. 48 S., R. 32 E. was drilled in 1977. The well is still being worked over and there are no production statistics available.

Because of the presence of pooled oil within, and immediately adjacent to the reservation, the prospects for finding additional Sunniland reserves and extension of the Seminole field in the reservation are indeed encouraging. Also, because of good oil shows, the discovery of oil in the Fredericksburg is still possible. Reflecting these favorable prospects, the Diamond Shamrock Oil and Gas Company have four proposed drilling locations in the reservation in sections 23 and 24, T. 48 S., R. 32 E., and the Houston Oil and Mineral Corporation has three proposed drilling locations in the western part of the reservation in sections 25, 26, and 28, T. 48 S., R. 34 E. (Figure 10).

Recommendations

Since high-silica sand is being profitably mined on the reservation, a drilling program should be undertaken to delineate the limits of the deposit. Additional test drilling should be conducted to determine if similar deposits occur in other parts of the reservation.

Programs leading to further development of oil and gas potential are being carried out by private industry with permission of the tribe. Accelerated interest in developing domestic petroleum resources will continue to give impetus to these programs and further exploration on the reservation should need no more than continued tribal support.

MICCOSUKEE RESERVATION

Introduction

Miccosukee Reservation is in western Broward County. The northern boundary is common with part of Big Cypress Reservation (Figure 9). All 76,000 acres are tribally owned and under State of

Florida jurisdiction. Miccosukee Reservation is in Water Conservation Area 3 and easements restrict land use to boating, hunting, fishing, and limited grazing.

A government road crosses the reservation north to south, allowing access to the State toll road, route 84. Rail connections are not available near the area.

Topography, physiography, and vegetation in the area are similar to that of Big Cypress Reservation.

Geology

Bedrock on the reservation is the Pleistocene Fort Thompson Formation which consists of alternating marine and fresh-water shell marls and limestones (Vernon and Puri, 1964). The maximum thickness is 20 feet but is commonly less than 10 feet (Parker and Cooke, 1944, p. 73). The Fort Thompson Formation was probably deposited uniformly over the irregularly eroded surface of the Caloosahatchee Marl so that thickening and thinning are related to depositional history rather than to structural deformation.

Mineral Resources

Minerals have never been produced from the reservation and potential for future development is limited. The reservation is on the margin of extensive Everglades peat deposits. Corps of Engineers' borings on the reservation show peat thickness between 0 and 2 feet. These logs indicate that sand of the Pamlico terrace, as mined on Big Cypress Reservation, is practically nonexistent on Miccosukee land. Phosphate was noted in only one boring (Table 3). Marl could be mined for local road construction.

No oil exploratory wells have been drilled on the Miccosukee Reservation nor, for that matter, in all of Broward County (Figure 10). This region is wide open for oil and gas exploration and because of accelerating depletion of national oil reserves it is highly recommended that this area be tested.

One bright and encouraging piece of news is the very recent discovery by Exxon of a possible new field about 3¼ miles (5.2 km) west of the southwestern most corner of the reservation near the intersection of Broward, Dade, and Collier Counties (see Figure 9) (Fietz, Exxon Company, 1977, personal commun.). The well is the Exxon #33-4 Oleum Corporation in sec. 33, T. 51 S., R. 34 E., Collier County. No production data are available.

Because of the proximity of this probable oil discovery to the reservation, and the fact that the southern part of the reservation is within or adjacent to the apparent Sunniland producing trend, initial exploration should be in the southernmost part of the reservation.

Recommendations

Miccosukee Reservation is in Water Conservation Area 3 and development of mineral resources would require a permit from the State. Past policy has been to deny applications for mineral development. Even if State policy were to change, other than petroleum exploration by private interests, no recommendation for field studies is proposed

because of the reservation's limited mineral potential.

BRIGHTON RESERVATION

Introduction

Brighton Reservation in Glades County comprises 35,058 acres which are tribally owned (Figure 11). Access is from the north via State highways 70 and 721. Highway 721 bisects the reservation and connects to the south with the State road system circling Lake Okeechobee. Nearest rail transportation is the Southern Coastline Railroad at the town of Okeechobee about 20 miles northeast, and Moore Haven about 15 miles south. Moore Haven is also a port on the Intracoastal Waterway that connects Stuart on the Atlantic Coast, with Fort Myers on the Gulf Coast.

Drainage throughout the area is poorly developed. Two streams, Kissimmee River and Fisheating Creek, have headwaters in the higher elevations of terraces older than those on the reservation and empty into Lake Okeechobee. These weed-choked streams have low gradients, broad shallow valleys, and have little influence on drainage.

Brighton Reservation is underlain by the Caloosahatchee and Fort Thompson Formations (Vernon and Puri, 1964). The Caloosahatchee Formation consists predominantly of shells cemented with clay and has a thickness of 30 to 50 feet (Cooke, 1945, p, 214-215), Fort Thompson Formation is composed of alternating fresh-water marl and limestone and marine shell marl. The maximum thickness is not more then 20 feet (Cooke, 1945, p. 249). In the reservation, these formations locally are covered by unconsolidated sands of the Pamlico and Talbot terraces.

Mineral Resources

General

Mining on the reservation is restricted to coquina for road metal. However, there are reports of phosphate pebbles in the beds of Fisheating Creek and Kissimmee River; heavy-mineral concentrates in the area may occur on the reservation; and a magnetic anomaly in underlying rocks may indicate a subsurface structure capable of trapping oil and gas.

Nonmetallic Mineral Resources

Sand.--Sand is plentiful in southern Florida but is often contaminated by tannic acid, shells, or clay. Clean sand for aggregate is in short supply. The high silica sand of the area is suitable for aggregate. Demand permits longer haulage distances than would normally be profitable and a deposit of clean silica sand on the reservation could be a valuable resource.

Pleistocene terraces covering the reservation are commonly unconsolidated sands. Geological cross sections, prepared by the Corps of Engineers for construction of Indian Prairie and Harvey Pond canals, show that the eastern and northwestern portions of Brighton Reservation are covered by sand 20 feet or more thick. The quality of this sand is unknown and should be evaluated.

Stone.--Coquina for road metal has been mined in T. 39 S., R. 33 E. Most of the stone on the reservation is covered by unconsolidated sand, making evaluation difficult.

Materials of this type are abundant outside the reservation and there is little possibility of expanding quarry activity.

Phosphate.--Florida's valuable land pebble phosphates lie 50 miles east of the reservation, but river pebble phosphates have been reported in Kissimmee River and Fisheating Creek, both near the Indian lands (Figure 11).

The term "river pebble" refers to concentrations of phosphate nodules that occur in river beds, either in present or earlier channels and flood plains (Sellards, 1915; Mansfield, 1942; Matson, 1915). All river pebble phosphate deposits are similar in that concentration of the nodules is the result of stream action. However, source areas may be quite different.

Most of the streams from which river pebble phosphates have been produced flow across formations that are sufficiently rich to be mined for land pebble or hard rock phosphates. Phosphates in some streams, such as the Caloosahatchee River, was probably derived in the phosphatic Tamiami Formation by the Caloosahatchee River (Buckingham Marl of Parker, 1944; Klein and others, 1964, p. 88, 92, 97). Fisheating Creek and Kissimmee River do not flow across phosphate-rich formations. These streams flow over Pleistocene and Recent strata where phosphate nodules, eroded from earlier formations, are randomly and sparsely distributed. Because source rocks are lean, economic concentrations of "river pebble" phosphate are probably not present in these streams or on adjacent lands.

Heavy Minerals.--Florida sands are a major source of concentrations of the heavy minerals ilmenite, leucoxene, zircon, and rutile. Some deposits also yield monazite and staurolite. The most valuable concentrations have been shown to occur on the outer edge of coastal bars of Pleistocene terraces (MacNeil, 1950, p. 95). At present, Florida's largest production is from a deposit associated with the Sunniland terrace in northern Florida. Several deposits of heavy minerals, associated with the Pamlico terrace, were mined in Florida in the 1940's and 1950's (Mertie, 1958, p. 9-12).

The 25-foot contour which roughly delineates the Pamlico shoreline passes diagonally across the reservation (Figure 11). No record was found of prospecting for heavy minerals within 50 miles of the reservation. However, the persistent association of heavy minerals with the Pamlico terrace suggests the possibility of occurrences all along this ancient shoreline and drilling might reveal a deposit on the reservation.

Energy Resources

Oil.--Wildcat activity on the Brighton Reservation and the nearby vicinity has been nil. The closest wells in any direction are more than 10-15 miles away from the reservation and they are all dry holes. The Brighton Reservation is also some 35 miles northeast of the current Sunniland producing trend (Figure 8).

Because of the dearth of exploratory wells and geological information, it is difficult to make a solid assessment of the petroleum potential of the Brighton Reservation. However, because of the poor showings of the closest wells and the far distance of the Brighton Reservation from the Sunniland trend, the chances of finding any sizeable commercial accumulation of Sunniland oil in the Brighton Reservation is certainly much less than on the other two reservations. There is a better chance, however, of finding some Fredericksburg oil on the Brighton Reservation and nearby vicinity than in many other areas of the South Florida Basin. The areas, including the Brighton Reservation, that are most favorable for finding oil in unit "C" of the Dollar Bay Formation of Fredericksburg age are shown on Figure 12.

A magnetic survey of Florida (Lee and others, 1945, p. 5) indicates that Lake Okeechobee is coincident with a strong magnetic low in the crystalline basement. This may indicate a structure which, if reflected in overlying sedimentary rocks, might provide a trap for oil and gas.

Recommendations

Brighton Reservation may have deposits of silica sand and/or heavy minerals associated with thick Pleistocene sands that cover parts of the reservation. A field examination is recommended to determine which deposits of these resources are present.

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Click back button (<<) on toolbar to return to text

Table 1.--Generalized stratigraphic section of central Florida
(from Applin and Applin, 1965; Brooks, 1968;
Cathcart, 1968; Cooke, 1945; Du Bar, 1958;
Klein and others, 1964; Olsson, 1968;
Parker and others, 1955; Rainwater, 1971)

Age	Formation Name	Lithology	Thickness (feet)
Recent Series	Lake Flint Marl	Organic soil, peat, fresh water marls.	Generally thin; as much as 8 feet.
Terrace deposits	Pamlico and Talbot terraces	Sand.	2 to 3 ft.; locally 15 ft in depressions.
Pleistocene Series	Fort Thompson	Fresh water marls, fossiliferous limestone, terrestrial deposits.	2 to 20
Pliocene Series	Caloosahatchee Marl	Sand and friable sandy shell marl.	15 to 30, discontinuous, deposited in depressions on Tamiami Formation.
Miocene Series	Tamiami Formation	Fossiliferous and locally phosphatic, soft, sandy limestone, sandy marl, layers of hard porous limestone, beds of fine quartz sand.	70 to 120
	Hawthorn Formation	Light green sandy marl, white to green plastic clay, finely crystalline limestone, silty sands and quartz pebbles. Phosphorite grains and pebbles common.	300 to 500
	Tampa Formation	Permeable limestone, friable calcareous sandstone, few beds white chalky marl.	15 to 190
Oligocene Series	Suwanee Limestone	White, finely porous limestone, partly dolomitized.	Feather edge to 570.

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Age	Formation Name	Lithology	Thickness (feet)
Eocene Series	Ocala Limestone	Fossiliferous chalky limestone.	150 to 390
	Avon Park Limestone	Tan to white, chalky limestone with many microfossils.	200 to 390
	Lake City Limestone	Brown, crystalline dolomite, dolomitic limestone, and permeable limestone.	300 to 400
	Oldsmar Limestone	Fragmental marine limestone, lenses of chert, few shale beds, some gypsum impregnations.	400 to 1,670
Paleocene Series	Cedar Keys Limestone	White to cream fragmental limestone, dolomite, and anhydrite.	1,400 to 2,400
Upper Cretaceous (Gulfian) Series		Chalk, limestone, and dolomite. Some anhydrite.	2,000 to 3,000
Lower Cretaceous (Comanche) Series	Washita Group	Calcitic dolomite interbedded with lenses of anhydrite and chalky limestone.	1,000 to 1,326
	Fredericksburg Group	Brown dense limestone and brown dolomite in lower part and cream chalky limestone in upper part. Bioclastic limestone irregularly distributed throughout. Anhydrite beds common locally.	1,000 to 1,400
	Trinity Group		
	Unnamed section	Argillaceous limestone interbedded with dolomites and anhydrites.	400
	Lake Trafford Formation	Anhydrite	100

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Age	Formation Name	Lithology	Thickness (feet)
	Sunniland Limestone	Limestone-oil producer	280
	Punta Gorda Anhydrite	Thick anhydrites with thin beds of limestone and dolomite.	600
	Unnamed group	Limestones, dolomites, and anhydrites. "Brown Dolomite zone." About 100 feet--potential oil reservoir rock.	500
Upper Jurassic(?) or Lower Cretaceous(?)	Fort Pierce Formation	Red, coarse-grained arkosic sandstone, red calcareous sandstone and interbedded red and varicolored shale; grade upward into interlayered carbonate rocks and evaporites.	490 to 2,200

Table 3.-- Phosphate occurrence in borings on Big Cypress and Miccosukee Reservations

Boring number	Surface elevation (feet)	Bed elevation (feet)	Overburden (feet)	Thickness (feet)	Description
Big Cypress Reservation					
23	+13.4	+6.7	6.7	6.0	Fort Thompson (?) Formation-- Sand, medium to coarse quartz, slightly shelly, cream to white; some phosphate granules
24	+13.9	-2.7	16.6	1.0	Caloosahatchee Marl-- Marl, very sandy, shelly, with granules of black phosphate, cream
24	+13.9	-3.7	17.6	4.3	Sand, fine to medium quartz, marly, very shelly, phosphatic, cream to tan
26	+12.5	-4.7	17.2	1.8	Tamiami Formation-- Sand, fine to medium quartz, very marly, very shelly, brownish-gray; with granules of phosphate; at -5.0 feet mean sea level
26	+12.5	-6.5	19.0	7.2	Sand, fine to medium quartz, very marly, white to light cream, shelly; pebbles and granules of phosphate
Miccosukee Reservation					
27	+12.1	+1.7	10.4	1.6	Fort Thompson Formation-- Marl, very sandy, shelly, cream; with some phosphate granules

(adapted from Schroeder and Klein, 1954)

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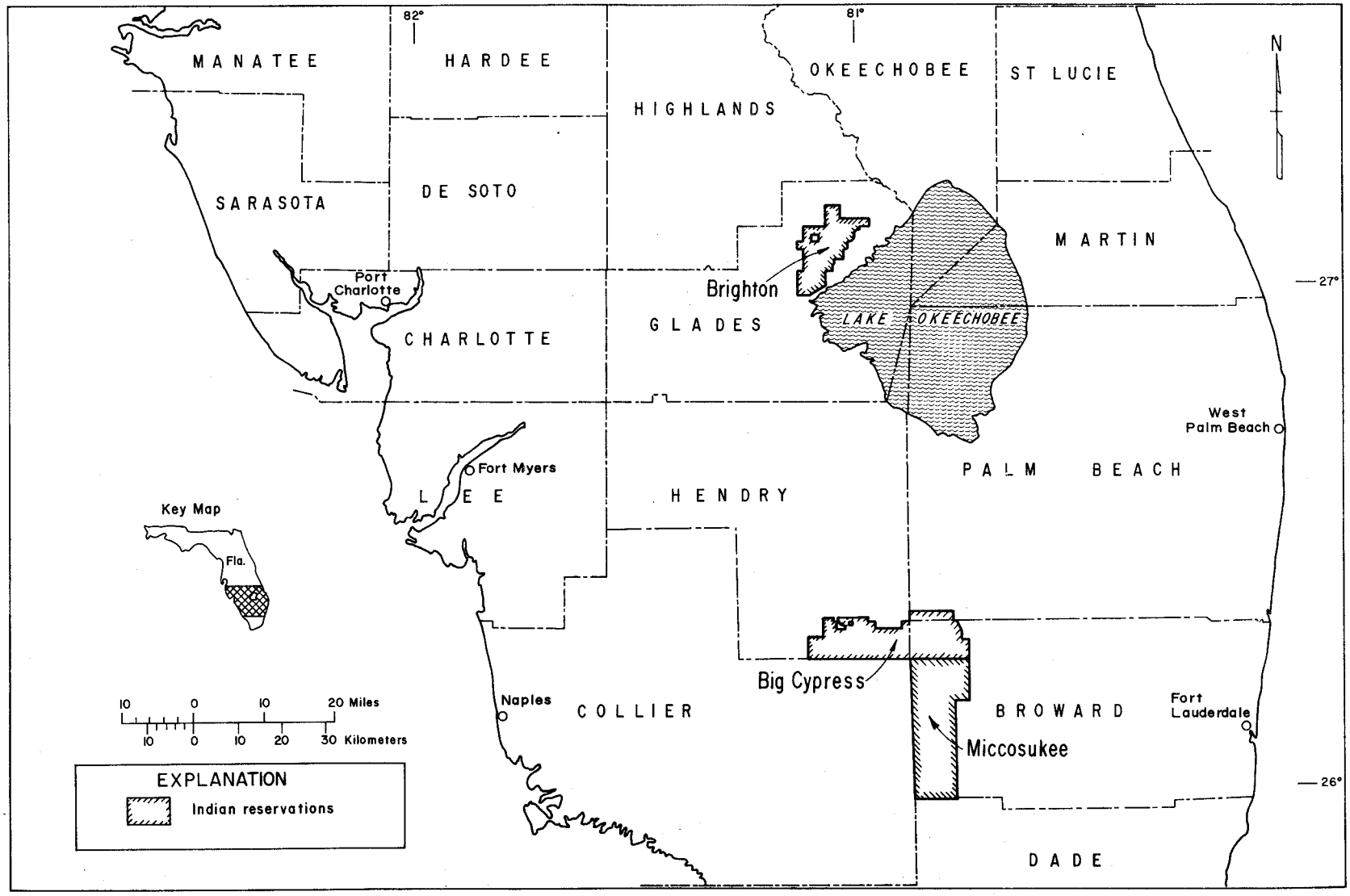

Figure 1. Map of Southern Florida, showing location of Big Cypress, Miccosukee and Brighton Indian Reservations.

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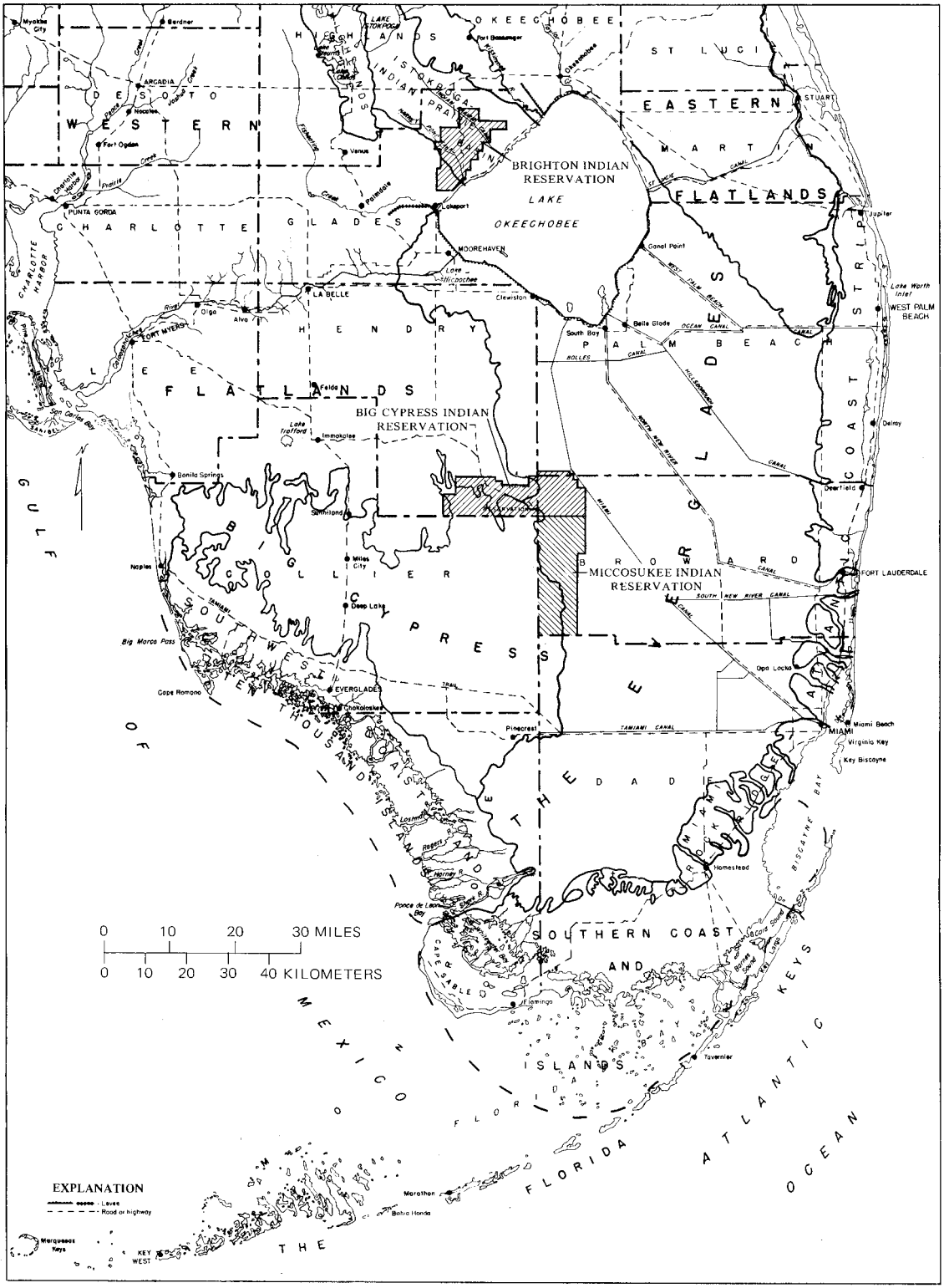

Figure 2. Map showing physiographic regions of Southern Florida (Davis, 1943, fig. 1).

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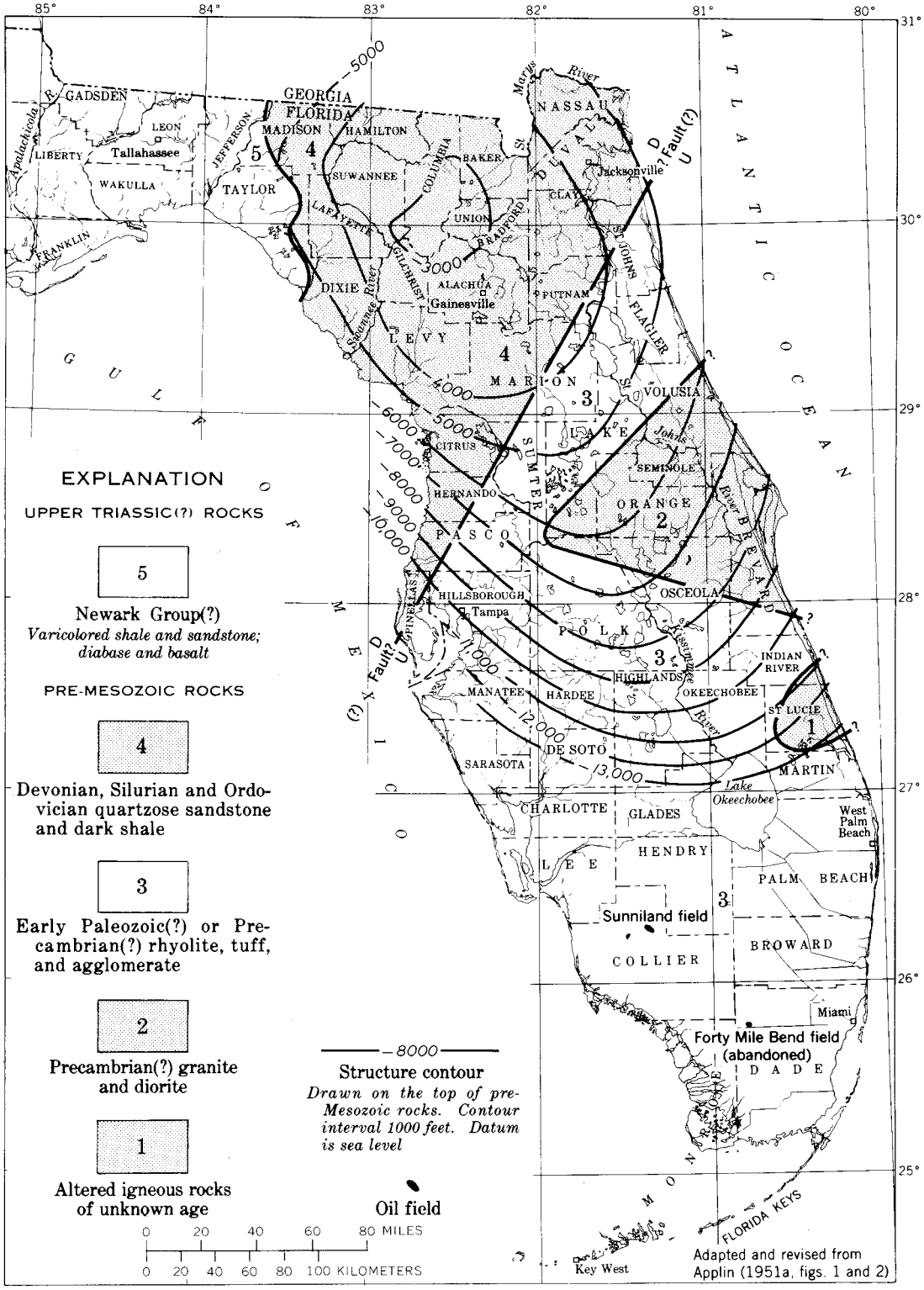

Figure 3. Map of the Florida Peninsula showing the areal distribution of pre-Mesozoic and upper Triassic(?) rocks that compose the coastal plain floor, and structure contours on the truncated surface of pre-Coastal plain rocks (from Applin and Applin, 1965, fig. 3).

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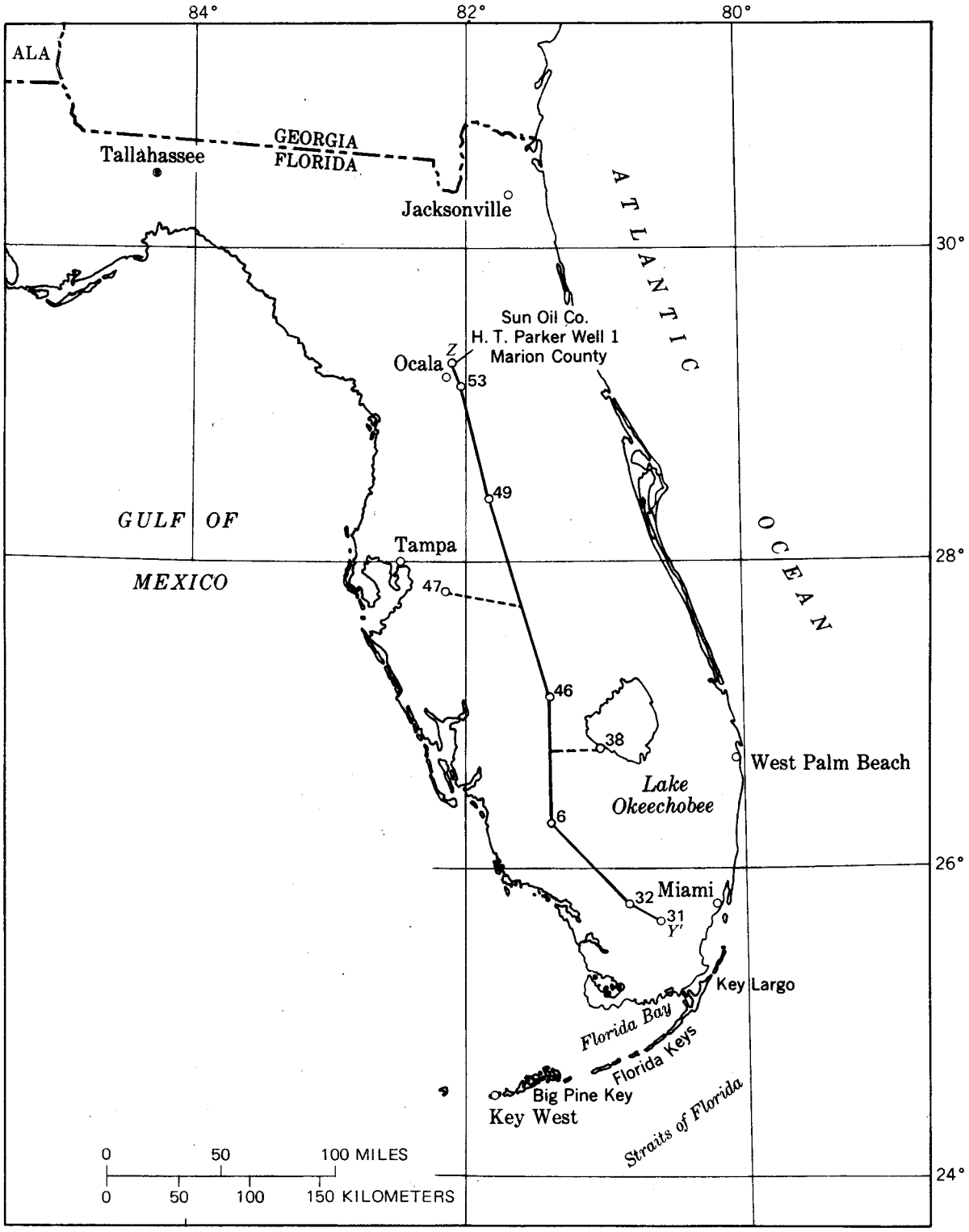

Figure 4. Index map of Florida showing well location for section X-Y' (Figure 5). Modified from Applin and Applin (pls. 9 and 11, and fig. 1).

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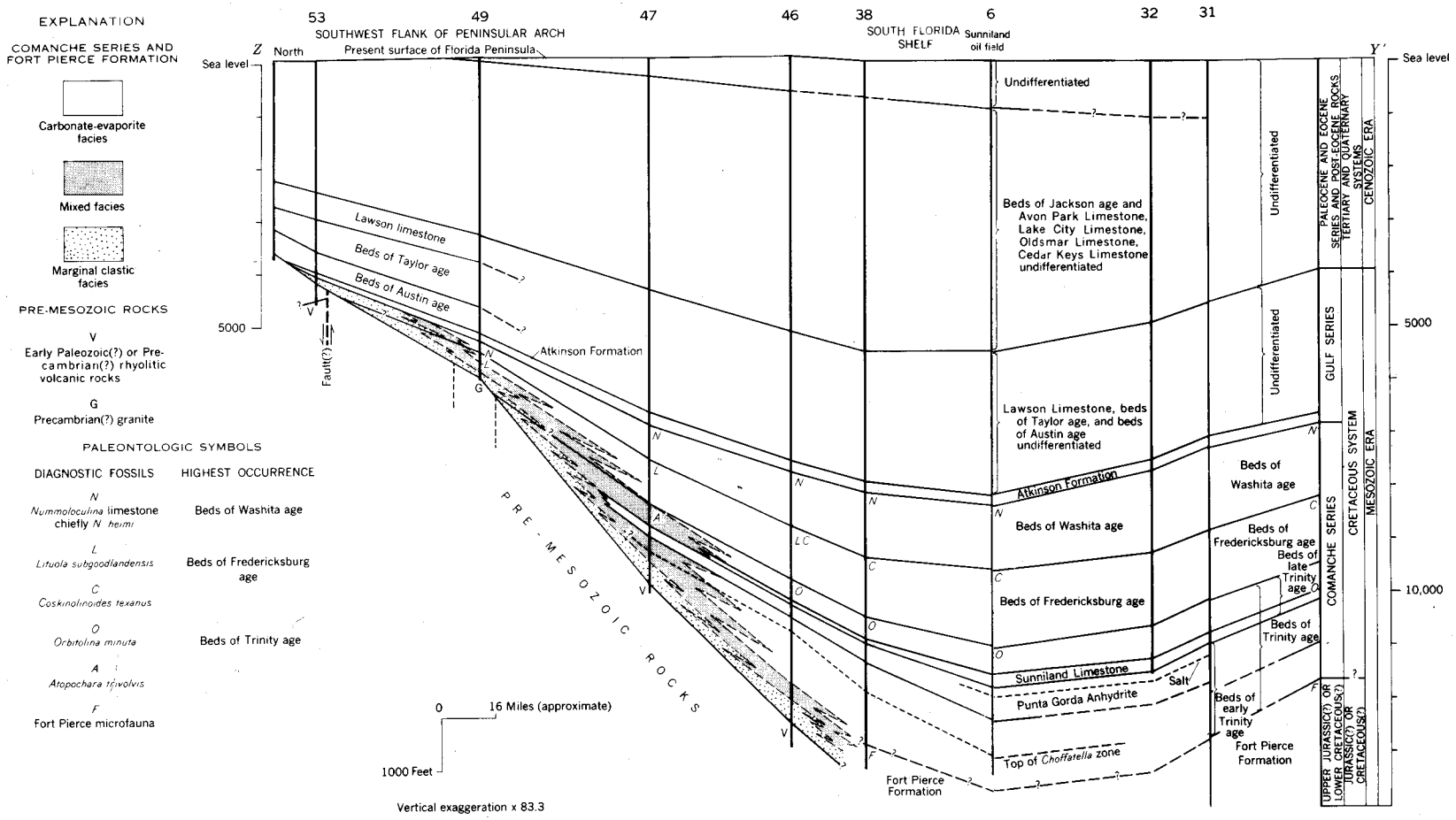

Figure 5. Diagrammatic section along X-Y' through wells in central and southern Florida. Modified after Applin and Applin (1965, pls. 9 and 11).

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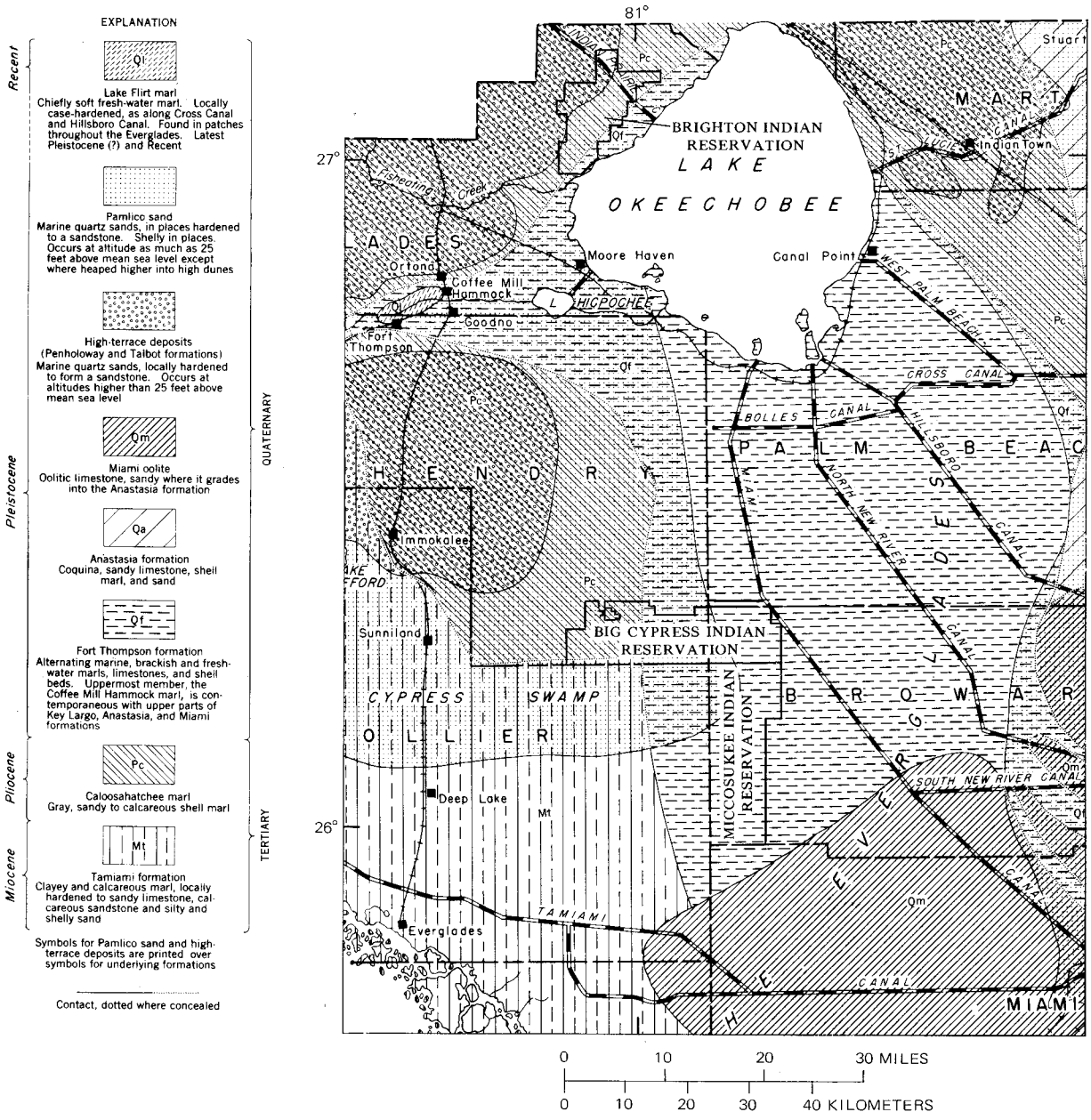

Figure 6. Geologic map of part of southern Florida (from Parker and others, 1955, pl. 4).

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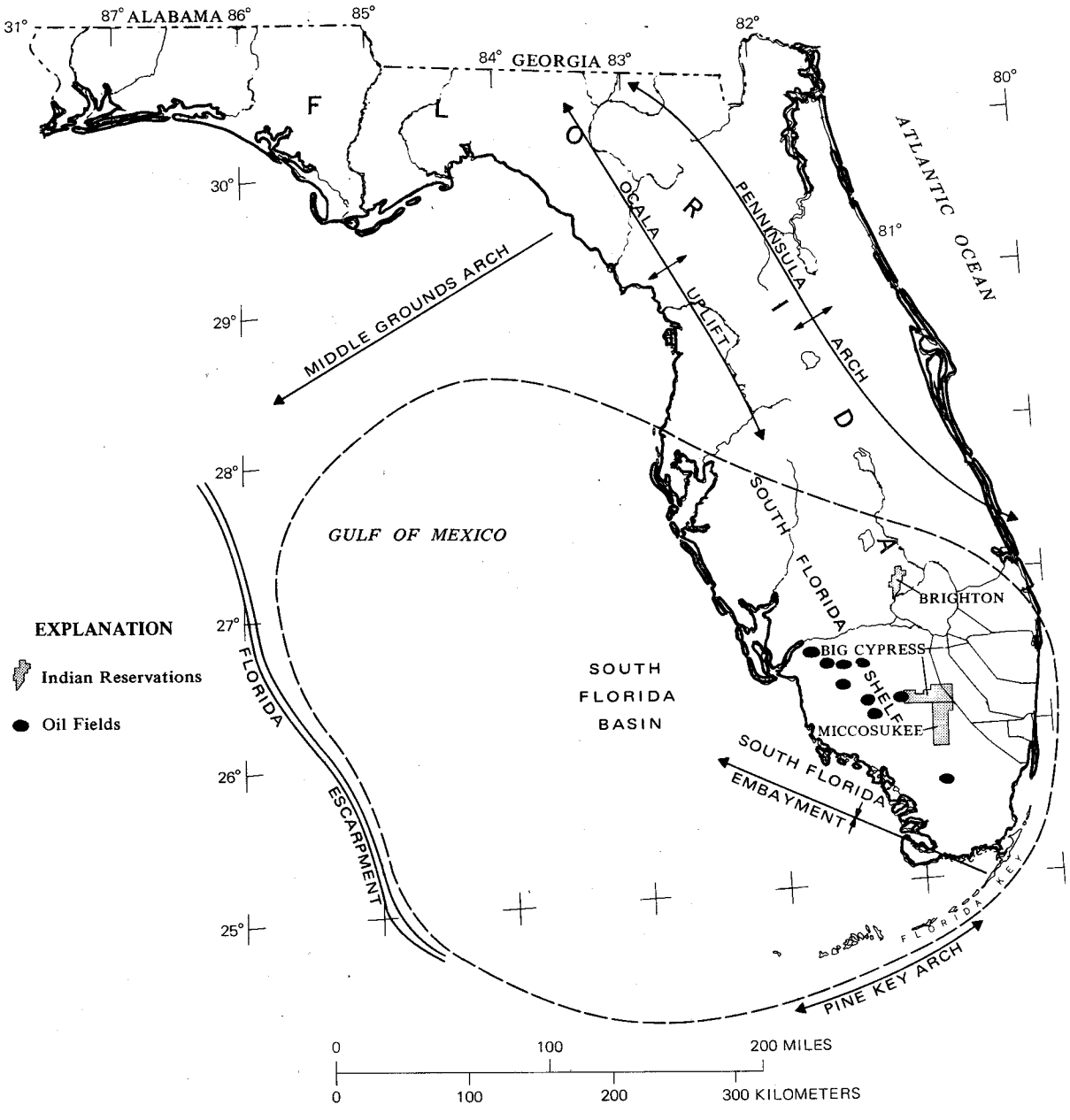

Figure 7. Map showing approximate outline of south Florida Basin, major structural features, and location of Indian Reservation, and oil fields. Modified after Applin and Applin (1965) and Winston (1971a).

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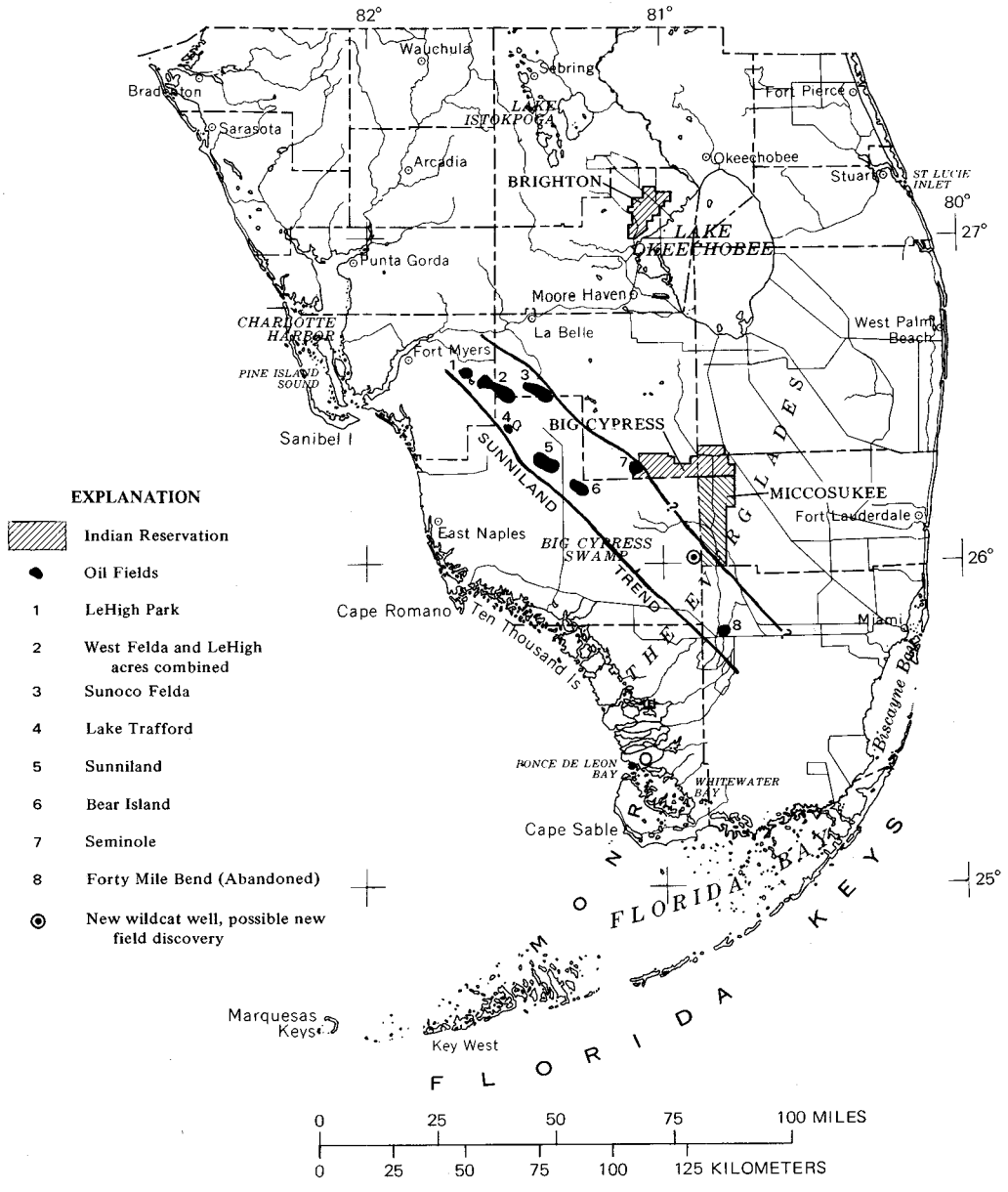

Figure 8. Map showing location of Sunniland producing trend, oil fields, and Indian Reservations.

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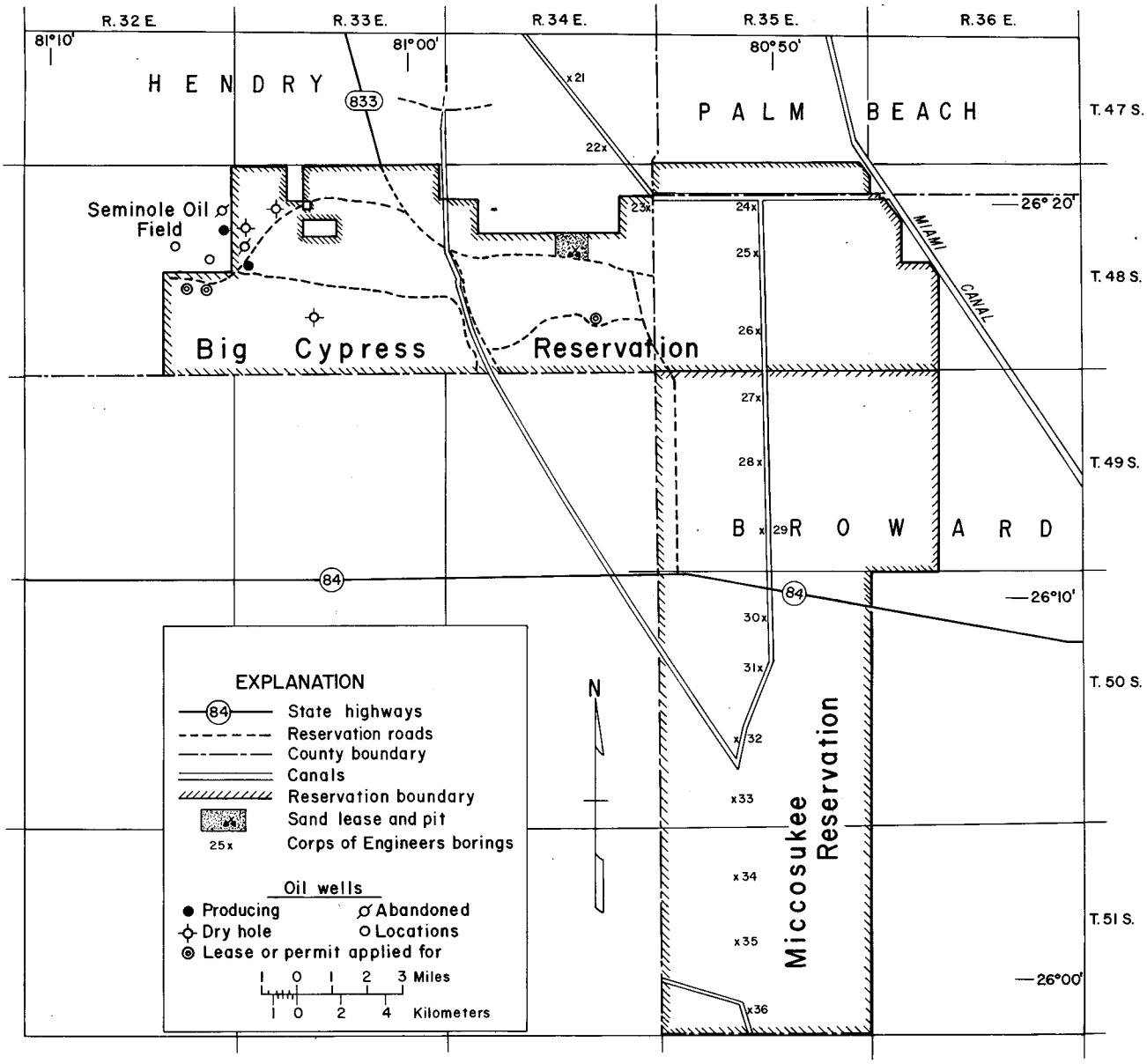

Figure 9. Index map, Big Cypress and Miccosukee Indian Reservations.

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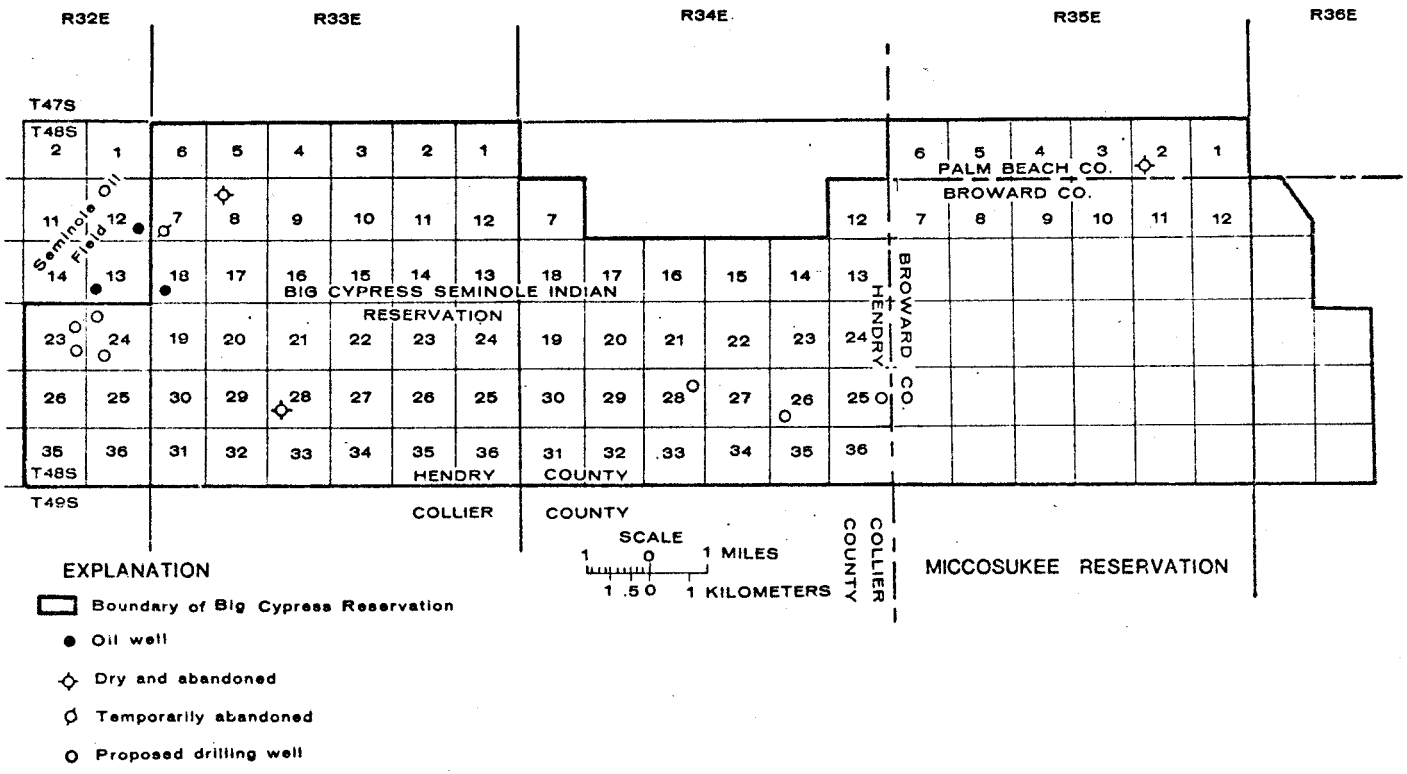

Figure 10. Map showing past and proposed drill sites on the Big Cypress Indian Reservation.

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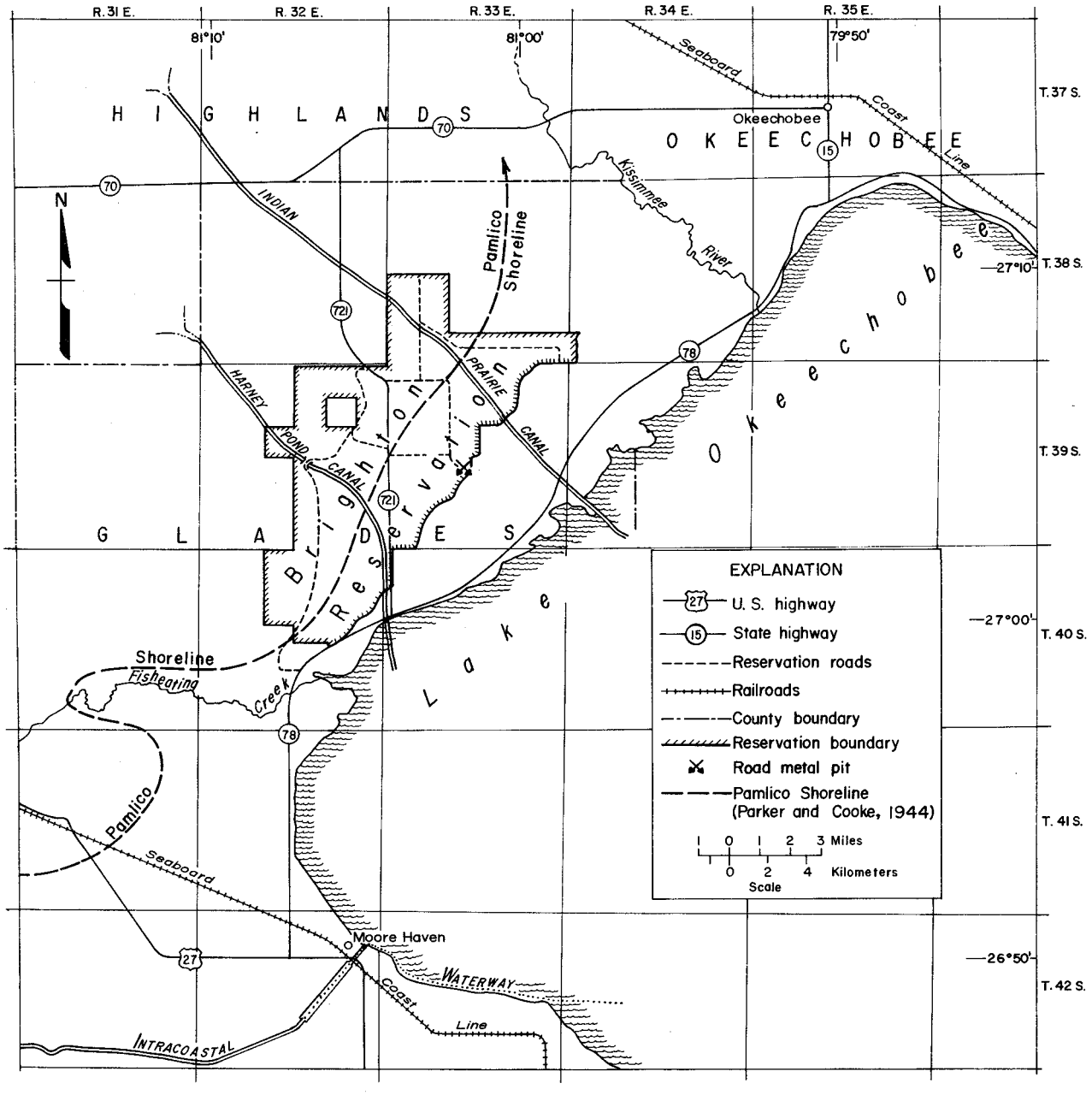

Figure 11. Index map of the Brighton Indian Reservation.

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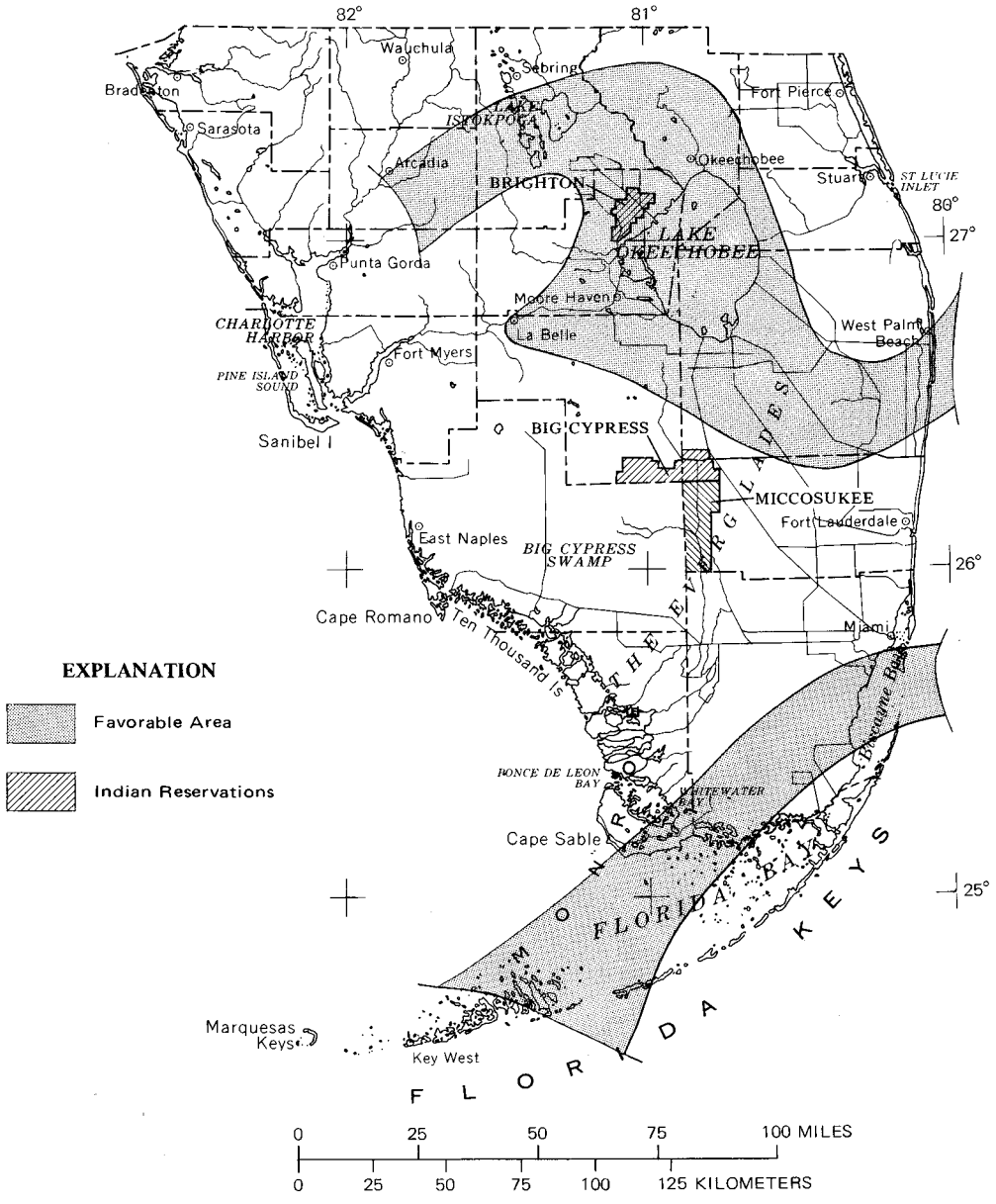

Figure 12. Map showing favorable areas (based on good porosity development and source rock potential) for oil exploration in unit "C", Dollar Bay Formation, Fredericksburg age (Winston, 1971b).